PCT WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 5 : G01T 1/167, G21C 17/02

A1

(11) International Publication Number: WO 94/29745

(43) International Publication Date: 22 December 1994 (22.12.94)

(21) International Application Number: PCT/SE94/00553

(22) International Filing Date: 8 June 1994 (08.06.94)

(30) Priority Data:
9301997-4 10 June 1993 (10.06.93) SE

(71) Applicant *(for all designated States except US)*: FORSMARKS KRAFTGRUPP AB [SE/SE]; S-742 03 Östhammar (SE).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)*: BJURMAN, Björn [SE/SE]; Majvägen 15, S-742 35 Östhammar (SE).

(74) Agents: LINDGREN, Anders et al.; Dr. Ludwig Brann Patentbyrå AB, P.O. Box 17192, S-104 62 Stockholm (SE).

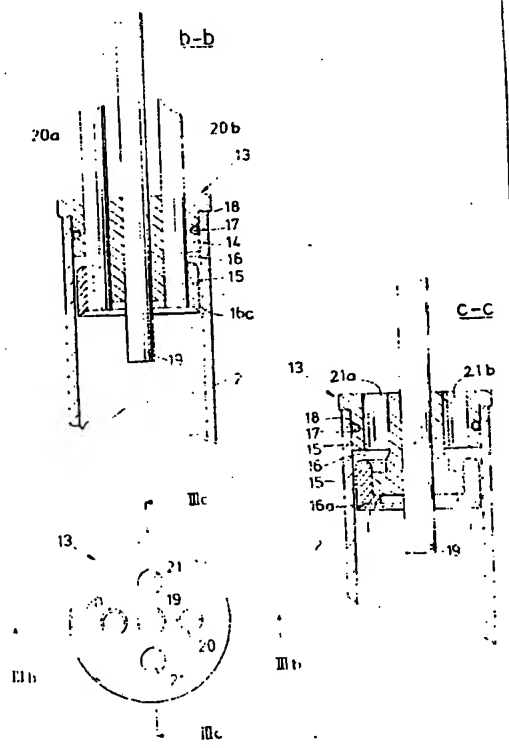
(81) Designated States: FI, JP, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
With international search report.
In English translation (filed in Swedish).

(54) Title: DEVICE FOR THE MEASUREMENT OF CONCENTRATION OF RADIOACTIVITY IN A LIQUID

(57) Abstract

The invention relates to an apparatus for measuring the radioactive concentration of a liquid, comprising an outer, vertically oriented cylinder (2) provided with means (5, 6) for supplying liquid to the outer cylinder (2). The liquid flows down through the cylinder (2) along its vertical shaft without being in contact with the inner surface of the cylinder (2). The apparatus is provided with a detector (7) for measuring the radioactivity in said liquid. There are means (3) for supplying a flushing liquid to the inner part of the cylinder (2) in such a manner that the flushing liquid flows downwards and forms a liquid film on the inner surface of the cylinder (2). The invention is characterized in that means (3) comprise at least one supply connection or supply pipe (21a, 21b) for supplying flushing liquid, which discharges somewhat above a column (16a) which runs along the inner surface of the cylinder (2) in order to produce said liquid film.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AT	Austria
AU	Australia
BB	Barbados
BE	Belgium
BF	Burkina Faso
BG	Bulgaria
BJ	Benin
BR	Brazil
BY	Belarus
CA	Canada
CF	Central African Republic
CG	Congo
CH	Switzerland
CI	Côte d'Ivoire
CM	Cameroon
CN	China
CS	Czechoslovakia
CZ	Czech Republic
DE	Germany
DK	Denmark
ES	Spain
FI	Finland
FR	France
GA	Gabon
GB	United Kingdom
GE	Georgia
GN	Guinea
GR	Greece
HU	Hungary
IE	Ireland
IT	Italy
JP	Japan
KE	Kenya
KG	Kyrgystan
KP	Democratic People's Republic of Korea
KR	Republic of Korea
KZ	Kazakhstan
LI	Liechtenstein
LK	Sri Lanka
LU	Luxembourg
LV	Latvia
MC	Monaco
MD	Republic of Moldova
MG	Madagascar
ML	Mali
MN	Mongolia
MR	Mauritania
MW	Malawi
NE	Niger
NL	Netherlands
NO	Norway
NZ	New Zealand
PL	Poland
PT	Portugal
RO	Romania
RU	Russian Federation
SD	Sudan
SE	Sweden
SI	Slovenia
SK	Slovakia
SN	Senegal
TD	Chad
TG	Togo
TJ	Tajikistan
TT	Trinidad and Tobago
UA	Ukraine
US	United States of America
UZ	Uzbekistan
VN	Viet Nam

DEVICE FOR THE MEASUREMENT OF CONCENTRATION OF RADIOACTIVITY IN A LIQUID.

The present invention relates to an apparatus and a process for measuring radioactivity in circulating water contaminated by radioactivity, for example, in a nuclear power plant.

BACKGROUND OF THE INVENTION

In nuclear power plants it is very important to keep strict control over the levels of various nuclides in the water which circulates in the system, so as to trace any errors in the system at an early stage. The most simple way of surveillance is by taking samples from the system at certain time intervals, and then analysing the samples for radioactivity in a laboratory. This process, obviously, only gives a momentary picture of the conditions in the plant, and furthermore, a delayed picture, and since the nuclide levels may vary considerably within the time range of minutes, one realizes that there is a need for a set of apparatus providing more or less continuous measurments.

STATE OF THE ART

An apparatus of the type mentioned in the preamble is known, i.a. from JP-C-55581/77 and JP-C-137595/77.

JP-C-55581/77 discloses, for example, an apparatus having a vertically arranged water-releasing pipe through which the radioactive liquid to be measured flows. A measuring cylinder, having a diameter which is greater than that of the water-releasing pipe is arranged coaxially with the water-releasing pipe, allowing the radioactive liquid to flow down into the

measuring cylinder along its vertical longitudinal axis. The end of the water-releasing pipe extends into the measuring cylinder so that the radioactive water is not brought into direct contact with the inner surface of the measuring cylinder. As a result, the risk of radioactivity accumulating on the measuring cylinder's surface is reduced. A detector for measuring radioactivity is arranged on the outside of the measuring cylinder and measures the concentration of the radioactivity in the radioactive liquid without being in contact with the measuring cylinder. The water passing through the measuring cylinder is discharged through a discharge opening via a water outlet pipe arranged on the measuring cylinder's outlet side, and then via a check or stopvalve, to a tank.

The problem with this known apparatus is that accumulation of radioactivity on the inner surface of the measuring cylinder cannot be avoided despite the fact that the liquid in the stream is not in direct contact with the measuring cylinder. Splashing, caused by fluctuations in the measuring stream, in the course of time results in such accumulation.

JP-C-137595/77 discloses an apparatus of mainly the same basic structure as the last mentioned apparatus, but with the additional characteristic that in the upper part of the measuring cylinder there is a twin-tube structure, whereby the inner tube or pipe element, i.e. the discharge pipe, directs the water to be measured for radioactivity and causes a vertical flow down through the measuring cylinder. Furthermore, clean water is supplied to the outer measuring cylinder in such a way that the clean water runs along the inner surface of the measuring cylinder and thus forms a protective film of clean water which reduces the risk of contamination on the inner wall of the measuring cylinder.

The latter apparatus is impaired by the disadvantage of the great amounts of flushing liquid which are needed in order to ensure a homogeneous cleaning film on the inner surface of the measuring

cylinder, without formation of "tracks" i.e. breaks in the continuous film which are quickly transmitted to the inlet pipe's opening. Due to the large amounts of cleaning liquid required there are problems handling the waste, i.e. the radioactive contaminated test liquid mixed with cleaning liquid.

EP-B-0 053 364 discloses an apparatus comprising a vertically arranged outer cylinder, means for measuring radioactivity, means for supplying a radioactive liquid to the inner part of the outer cylinder, and means for supplying cleaning liquid along the inner surface of the outer cylinder. With this apparatus one has tried to solve the problem of the large amounts of contaminated waste by returning the liquid to the enclosed system. However, this system requires that the analysing equipment is pressurized to the prevailing pressure in the primary cooling circuit or cooling water, which may amount to up to 70 bar. For obvious reasons this requires complex equipment, resulting in high costs.

EP-B-0 143 162 discloses a further development of the technique from the last mentioned patent. The detector for the radioactivity is arranged inside an inner cylinder, and the test flow is arranged in a ring-formed flow around the inner cylinder. To avoid contamination two flushing flows are produced, one along the inner cylinders exterior and one along the outer cylinder's interior surface.

THE TECHNICAL PROBLEM

The object of the present invention is, thus, to solve the problem which still exists with the known arrangements for measuring radioactivity in water from, for example, the cooling system of a nuclear power plant, i.e. to make it possible to measure radioactivity in such water, whereby only small amounts of sample water need be taken. Furthermore, only very small amounts of cleaning fluid should be required, and the measuring should be undertaken without the measuring equipment being contaminated accumulatively when measuring. The system should be

able to be maintained with mainly normal pressure. The waste water should be able to be handled in the same way as ordinary low active waste.

This problem is solved by a device according to claim 1.

The advantage with this device is, thus, that one does not risk the build-up of (radio)activity in the measuring chamber, and that the amount of waste may be kept low.

An especially preferred embodiment is defined in claim 2, and further embodiments are disclosed in claims 3-10.

The invention will now be described in more detail with reference to the attached drawings, where

Figure 1 illustrates a device according to the state of the art;

Figure 2 illustrates schematically the device according to the invention;

Figures 3a-c illustrate the construction of the inlet of the measuring apparatus, with means for producing the flushing flow; and

Figure 4 illustrates in detail an alternative embodiment of a buffer arrangment in the measuring cylinder.

The device illustrated in Figure 1, according to the state of the art (JP-C-137595/77), shows a measuring cylinder which consists of the outer casing of the device. In the measuring cyclinder's upper part there is a twin pipe structure, whereby the inner cylinder element, or the discharge pipe, leads the water the content of radioactivity of which is to be measured, and produces a vertical stream down through the measuring cylinder. Furthermore, clean water is supplied to the outer measuring cyclinder

in such a way that it runs along the inside surface of the measuring cylinder, thereby forming a protective film of clean water, thus reducing the risk of contamination of the inner wall of the measuring cylinder.

Figure 2 illustrates schematically an embodiment of the device according to the invention, generally denoted 1. This device has an outer cylinder 2, on which at the upper end there is arranged a means 3 for producing a thin flushing film 4 along the inner surface of the cylinder 2, and means 5, for producing a down-flowing stream 6 of radioactive water to be tested for radioactivity. The dimension of the cylinder 2 is not critical, but test cylinders having an outer diameter of 50 mm have been used with good results. Means 3 and 5 will be described in more detail hereinbelow.

A detector 7 for measuring the radioactivity (for example a Germanium detector 25% relative effectiveness) is arranged further down on the outside of the cylinder. The choice of detector is, obviously, completely dependent upon the measuring-conditions and it is within the field of competence of one skilled in the art to select the appropriate detector, therefor detectors will not be discussed here.

The detector is placed in a casing 8 made of, for example, lead and copper, to minimize both outer as well as inner radiation fields. On the opposite side of the cylinder 2 is a lead screen 9, provided with a copper lining 10 to further svield or screen off the system against exterior interference.

Further down the cylinder 2 a honeycomb structure 11 is arranged over the cross section of the cylinder. Said honeycomb structure 11 prevents splashing which occurs when the test-stream 6 falls down on the bottom of the device and reaches up to the area of the detector 7 and contaminates the inner surface of the cylinder 2 with radioactivity.

The honeycomb structure 11 is suitably built of a thin material, for example, a metal sheet, having a thickness of about 0.1 mm, which thickness, however, is not critical, and should have an extension (the thickness of the honeycomb) in the longitudinal direction of the cylinder 2 (i.e.the honeycomb's thickness) which amounts to about 15-20 mm.

Above the honeycomb structure 11 an O-ring 12 is arranged. Its function will be described in conjunction with means 3 and 5.

Figures 3a-c illustrate in detail an embodiment of a construction in the upper end of the cylinder 2. At said end there is an insert 13. This insert consists of an upper part 14 and a lower part 15 which are connected by means of a web or waist 16. The insert 13 may, preferably, be made in one piece from turned steel. The upper part's diameter is adjusted to fit in the cylinder 2 by means of press fitting and for the purpose of achieving an additional caulking against the inner surface of the cylinder 2, there is an O-ring 17 inserted in a groove 18 in the upper part 14.

The diameter of the lower part is somewhat less than the inner diameter of the cylinder 2 so that a column or slot 16a of at most 0.3mm, preferably at most 0.1mm is provided between the lower part 15 of the insert 13 and the cylinder 2.

Through the insert 13 there is a measuring-stream pipe 19 passed through a central bore in the insert. The pipe extends downwardly about 10 mm from the lower part of the insert into the cylinder 2. Through this pipe the liquid the radioactivity of which is to be determined is pumped with a flow of about 50-100 ml/s.

Two further pipes 20a and 20b are passed through bores in the insert 13. These pipes may be necessary for leading away gases which have been dissolved in the water, for example radioactive inert gases which have degassed in the measuring chamber during

the process.

The rib 16 forms a ring shaped chamber between the upper part 14 and the lower part 15 of the insert 13. This chamber is a fundamental characteristic of the invention, which will be disclosed by the description which follows. Through the upper part 14 of the insert 13 two channels or bores 21a and 21b are provided through which cleaning liquid, for example, clean water, is guided to the chamber. This serves thereby as a pressure equalizing or pressure distribution chamber and distributes the through the channels 21a and 21b incoming cleaning flow, in the ring shaped chamber, so when the liquid is forced out through the thin ring shaped column or slot 16a a homogeneous, mainly laminar flow along the inner side of the cylinder 2 is achieved.

The advantage of providing a cleaning film in this way is that to a great extent one eliminates turbulance, which would cause the thin film to very easily break up and form "bands or "strips" along the inside of the cylinder, i.e. places where no water flows. If this occurs, it is obvious that the cleaning will not be effective.

An alternative method of achieving that the distribution of the cleaning water forms a homogeneous film without turbulence is to supply the cleaning liquid in a plurality of thin pipes, distributed along the inner perifery of the cylinder 2 and opening immediately above the column (not illustrated).

A further method of achieving the distribution of the cleaning liquid is to supply the cleaning liquid tangentially by means of one or several pipes immediately above the column (not illustrated).

By means of the addition of surface tension reducing agents to the cleaning water, for example detergents of various kinds, an even flow is more easily obtained.

Although one achieves a homogeneous film along the inner side of the cylinder 2, due to the construction described above, "band formation" can arise because of microscopic and macroscopic irregularities in the path of the flow. For example, the honeycomb structure 11 described hereabove causes such irregularity in the flow path. Thus, if one does not take precautions the homogeneous film will infallibly be broken up as soon as the liquid comes into contact with the upper ridge of the "honeycomb"-insert 11. To eliminate this disturbance in the flow path a buffer volume of liquid is provided in a ring along the inner circumference of the cylinder 2. Such a buffer volume may be easily provided by means of, for example an O-ring 12 in the cylinder above the "honeycomb"-structure. As illustrated in Figure 3, a wedge-shaped space is formed between the O-ring and the inside of cylinder 2, around the perifery. This space acts so that small fluctuations in the liquid flow, caused by irregularities in the "honeycomb"-structure 11, are damped or accomodated in said buffer volume, so that the fluctuations cannot affect the flow above the buffer volume at said O-ring 12.

Obviously the necessary buffer volume can be achieved in other ways, for example, by constructing the cylinder 2 so as to be provided with a strip 22 on its inside whereby the strip has an upwardly extending rim 23 which forms the necessary ring shaped space 24. This is, obviously associated with higher costs, and said solution with an O-ring should be the simplest possible alternative.

By means of tests it has been shown that the detection level of analysis with the aid of the apparatus according to the invention, lies in the range of 200-500 Bq/kg. With previous methods the detection limits lie in the range of ten power higher. The detection limit depends, obviously, on the number, type and concentration of other nuclides in the sample water, but the tests show a clear improvement of the level of detectable nuclides.

CLAIMS:

1. An apparatus for measuring the concentration of radioactivity in a liquid, comprising an outer, vertically oriented cylinder 2, means (5, 6) for supplying the liquid to the outer cylinder 2 in such a way that the liquid flows down through the cylinder 2, along its longitudinal shaft without coming into contact with the inner surface of the cylinder (2), means (7) for measuring the radioactivity in said liquid, means (3) for supplying cleaning liquid to the interior of the cylinder (2) in such a way so that the cleaning liquid flows downwardly and forms a liquid film on the inner surface of the cylinder (2), c h a r a c t e r i s e d in that the means (3) comprises at least one supply conduit or pipe (21a, 21b) for supplying the cleaning liquid, which opens immediately above a column or slot (16a) running along the inside surface of the cylinder (2), for producing said liquid film.

2. The apparatus according to claim 1, wherein the pipe or pipes (21a, 21b) discharge into a pressure equalizing or pressure distribution chamber (16) which is connected to the inside of cylinder (2) via the column (16a).

3. The apparatus according to claim 2, wherein the ring shaped space and the column are formed by an insert (13) comprising a lower part (13) and an upper part (14), inserted in the upper part of the cylinder, and wherein the lower part (13) of said insert has a somewhat smaller diameter that the inner diameter of the cylinder (2), whereby the upper and lower parts (14, 13) are connected by means of a web or waist, which when the insert is inserted in the cylinder forms said pressure distribution chamber.

4. The apparatus according to claim 1, wherein the pipe or

pipes (21a, 21b) open out tangentially into the cylinder (2), immediately above the column or slot (16a).

5. The apparatus according to claim 1, wherein a set of pipes (21a, 21b) are arranged mainly vertically adjacent each other along the inner surface of the cylinder (2).

6. The apparatus according to any of the preceding claims, wherein the cleaning flow is 20-30 ml/s and the test liquid flow is 50-100 ml/s.

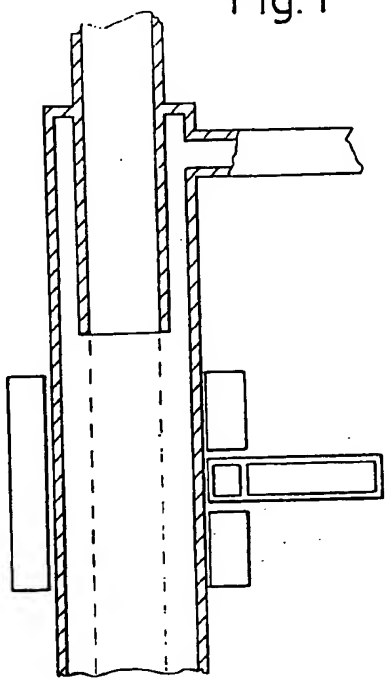
7. The apparatus according to any of the preceding claims, wherein the thickness of the film produced is less than 0.3 mm, preferably less than 0.1 mm.

8. The apparatus according to any of the preceding claims, comprising a ring shaped flange (22) arranged at the lower part of the cylinder (2), the rim of which is formed so that a ring shaped space forms between the rim and the inner surface of the cylinder (2).

9. The apparatus according to claim 8, whereby the flange (22) is formed by an O-ring (12) which is fitted into the cylinder (2).

10. Apparatus according to any of the preceding claims, comprising a splash-protecting means, consisting of a honeycomb-structure (11), which is inserted in the cylinder (2) and arranged below and adjacent the flange (22).

Fig. 1



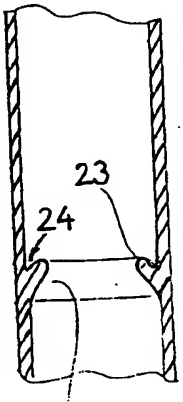


Fig 4

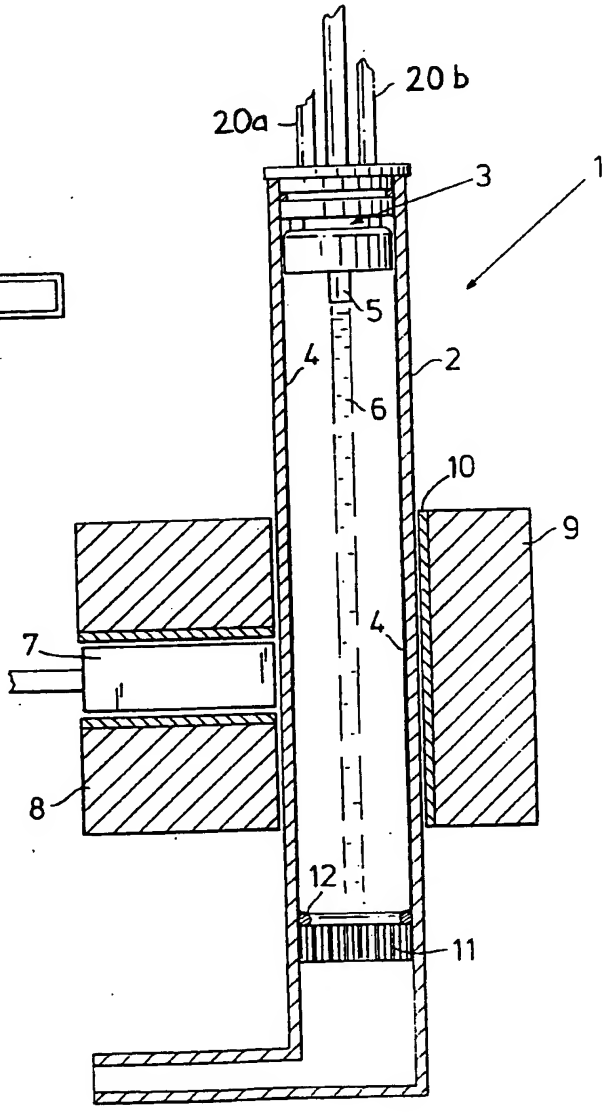


Fig. 2

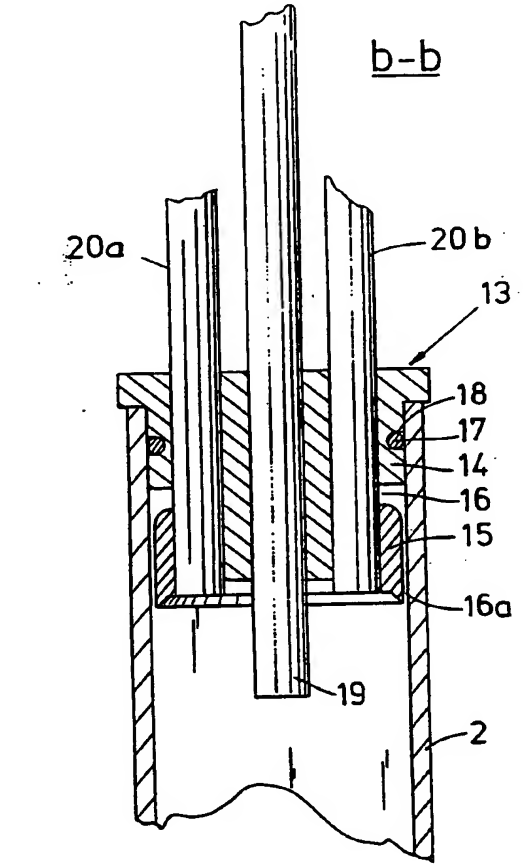
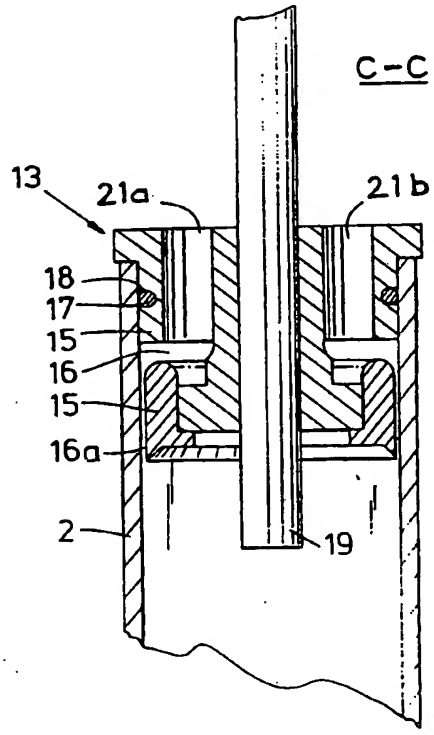
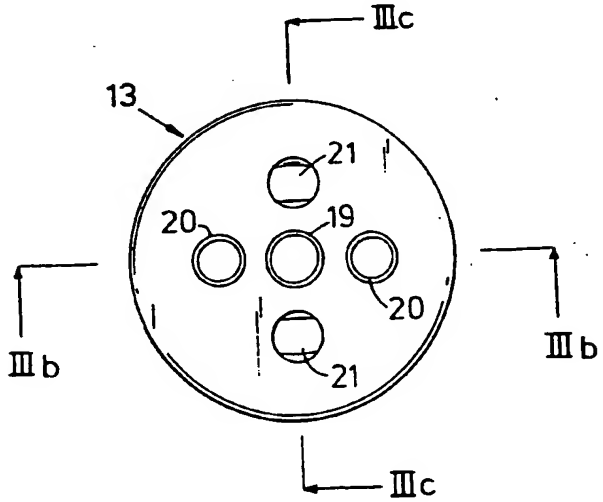

b-b
20a
20b
13
18
17
14
16
15
16a
19
2

Fig. 3 a-c


c-c
13
21a
21b
18
17
15
16
15
16a
2
19


IIIc
13
21
20
19
20
21
IIIb
IIIb
IIIc

a

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 94/00553

A. CLASSIFICATION OF SUBJECT MATTER

IPC 5: G01T 1/167, G21C 17/02
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 5: G01T, G21C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP, A1, 0143162 (HITACHI, LTD), 5 June 1985 (05.06.85), figure 7, abstract, cited in the description --	1-10
A	EP, A1, 0053364 (HITACHI, LTD), 9 June 1982 (09.06.82), figure 1, cited in the description --	1-10
A	Patent Abstracts of Japan, Vol 2,No 21, M-77, abstract of JP, A, 52-137595 (HITACHI SEISAKUSHO K.K.), 17 November 1977 (17.11.77), Cited in the application. Abstract in English --	1-10

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"B" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
9 Sept 1994	14 -09- 1994
Name and mailing address of the ISA/ Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Authorized officer Rune Bengtsson Telephone No. +46 8 782 25 00

INTERNATIONAL SEARCH REPORT

Information on patent family members

30/07/94

International application No.
PCT/SE 94/00553

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
EP-A1- 0143162	05/06/85	DE-A-	3472011	14/07/88
		JP-C-	1708470	11/11/92
		JP-B-	3074348	26/11/91
		JP-A-	60015578	26/01/85
		US-A-	4591716	27/05/86
EP-A1- 0053364	09/06/82	SE-T3-	0053364	
		JP-C-	1414662	10/12/87
		JP-A-	57093272	10/06/82
		JP-B-	62013634	27/03/87
		US-A-	4532103	30/07/85